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Citation for final published version:

Awange, J. L., Faisal Anwar, A. H. M., Forootan, Ehsan, Nikraz, H., Khandu, K. and Walker, J. 2018. Enhancing civil engineering surveying learning through workshops. *Journal of Surveying Engineering* 143 (3) 10.1061/(ASCE)SU.1943-5428.0000211 file

Publishers page: [http://dx.doi.org/10.1061/\(ASCE\)SU.1943-5428.00002...](http://dx.doi.org/10.1061/(ASCE)SU.1943-5428.00002...)  
<[http://dx.doi.org/10.1061/\(ASCE\)SU.1943-5428.0000211](http://dx.doi.org/10.1061/(ASCE)SU.1943-5428.0000211)>

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# Enhancing civil engineering surveying learning through workshops

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## Abstract

Civil Engineering Surveying unit at undergraduate level needs substantial amount of hands-on training to obtain adequate learning outcomes. Lecture-only mode of delivery does not provide adequate surveying skills needed by an engineering student. In 2009, workshops were introduced for this unit at Curtin University with the aim of offering students hands-on training in surveying to enhance their learning. This study analyses data collected from 160 students in 2012 and 2013 using confidence limits, correlations, frequency percentage distribution, and principal component analysis to evaluate if these workshops contributed to (i) enhancement of students' acquiring industry-based skills and (ii) enhancement of the students overall learning of engineering surveying, a practical oriented course. Additionally, qualitative analysis from Curtin's official eVALUate and examination results were used to verify the findings of (i) and (ii). The results indicate that workshops contributed to the development of the students' overall learning skills, with the top students' agreement being critical thinking skills (93.6%), handle problems (96.6%), and correlate theory (97.9%). Qualitative analysis of the 2013 data indicates that 70% of the students' agreed that their overall learning skills were enhanced, while the workshop sessions prior to the assessed fieldwork of setting out a horizontal curve enabled students to enhance their communication and teamwork skills. Overall, 97.9% of the students were satisfied with the workshops and 98.9% said they would recommend it as an effective learning tool to their friends. The main lesson that can be learnt from the data presented in this contribution is that students were satisfied with the workshops and recognise/perceive them to contribute to the development of the learning attributes they need to acquire.

**Keywords:** Workshop; Civil Engineering; Surveying; Learning attributes; Fieldwork; Critical Thinking

## 24 **Introduction**

25 Nowadays, tertiary education institutions seek to refine their engineering curricula to suit the most up-to-date  
26 technology and globalisation. In today's competitive world, therefore, it is necessary that university engineering  
27 graduates possess not only moral and ethical responsibilities needed to build a better liveable environment, but  
28 also certain generic competencies such as communication skills, teamwork, right attitudes, problem solving,  
29 creativity and critical thinking, and practical skills. This is because these young trained engineers would act as the  
30 bridge between the society and modern development on the one hand, while on the other hand, they are  
31 expected to meet the diverse range of needs of industries, governments and communities whilst continuously  
32 developing their professional skills (e.g., Male et al., 2009; Webster, 2000). In collaboration with Industry  
33 Advisory Committee (IAC) in Australia, for example, Male et al., (2009) identified four key competency skills out  
34 of 64 generic competencies namely: communication, teamwork, self-management, and problem solving skills as  
35 the most critical in performing the job well.

36 Whereas the normal traditional method of teaching and learning surveying through lectures and tutoring are  
37 required to enhance the student's theoretical skills, they are in themselves insufficient to produce a well-educated  
38 engineering workforce that is fundamental to innovation and entrepreneurship, and one that would directly  
39 contribute to global economy, environment, security and health (see e.g., Campbell et al., 2009). Hence,  
40 industries today seek engineering graduates who possess skills far beyond their classroom knowledge.

41 One approach that has been adopted to expose students to a variety of opportunities and knowledge, including  
42 creating awareness of global science and engineering trends, development of teamwork skills, fostering interest  
43 and motivation and peer interaction, is the *collaborative learning environment* (e.g., Webb, 1989; Bourner and Flowers,  
44 1997; Smith et al., 2005; Baroffio et al., 2006; Bartle et al., 2011). This approach enables these generic  
45 competency skills to be achieved through interactive learning methods such as face-to-face discussions (e.g., Ellis  
46 et al., 2008), project-based learning (e.g., Bartle et al., 2011; Fernandez-Samaca and Ramirez, 2010) and  
47 workshop-based learning (e.g., Anwar et al., 2012, 2013; Shelton and Hudspeth, 1989).

48 A workshop-based learning is an important component of collaborative learning method in the development of  
49 such skills in engineering learning (Shelton and Hudspeth, 1989; Anwar et al., 2012). It not only improves the  
50 student's overall performance through conceptual understanding, but also enhances their interest in the  
51 profession (e.g., Shelton and Hudspeth, 1989; Bourner and Flowers 1997; Anwar et al., 2012) and enables  
52 multiculturalism through close interaction with their tutors and colleagues (e.g., Watson et al., 1993). It makes  
53 them understand the real workplace environment and their role in the society better (Webster, 2000), while it  
54 also enhances the quality of tutor's teaching skills and understanding the student's problems, weaknesses, and  
55 how to solve them interactively (e.g., Pandachuck et al., 2004; Baroffio et al., 2006). This is demonstrated, e.g., in  
56 the works of Anwar et al. (2012), Fernandez-Samaca and Ramirez (2010), and Male et al. (2009), among others.

57 Workshops have been used in diverse professions to a diverse range of participants to enhance the learning  
58 outcomes (see, e.g., Skillen et al., 1998, Fullilove and Treisman 1990, Laws 1991, Dori and Belcher 2005, Parcell

59 et al., 1998 and Davis et al., 1999). In engineering teaching and learning, workshops have helped to improve the  
60 performance of students by developing a better understanding of the concepts. This is shown, e.g., in Shelton  
61 and Hudspeth (1989) where academic excellence workshop program that focused on enhancing engineering  
62 concepts such as statistics and dynamics to the students in an Engineering Mechanics course was implemented in  
63 California State Polytechnic University, Pomona in USA in order to increase the number of successful under-  
64 represented minority engineering graduates. Similarly, excellent workshop programs have resulted in a strong  
65 retention tool in the Minority Engineering Program in the College of Engineering and Applied Sciences at  
66 Arizona State University (Adair et al., 2001). Additionally, the workshop program managed to serve as an  
67 assurance and recruit more students in engineering (e.g., Anwar et al. 2013). An e-workshop pilot program  
68 launched in Riga Technical University, Riga, Latvia (Peteris et al., 2012), which was introduced in order to make  
69 students ready for practicals, resulted in good feedback from local and foreign students as well as interests from  
70 other universities in the city. Workshops, therefore, could contribute towards satisfying engineering bodies in  
71 various countries (see, e.g., Felder and Brent, 2003).

72 Whereas the preceding paragraphs highlight the significance of workshops in enhancing engineering learning in  
73 general, its application to the teaching and learning of engineering surveying, a fieldwork-based unit, is less  
74 documented. Part of the challenge is posed by the practical/fieldwork nature of engineering surveying that  
75 requires students to undertake field practicals where they learn practical skills of infrastructure setup. In  
76 undertaking fieldwork, the students are expected to utilize their communication and teamwork skills as they work  
77 within group environments. At Curtin University, students undertaking Civil Engineering Drawing and  
78 Surveying (CVEN2000) unit had only an hour lecture and a two-hour practical, which was insufficient for the  
79 students to grasp the vast subject of surveying, which is one of the key requirements in a civil engineering  
80 profession (see, Millis and Barber, 2004; Scheofield and Breach 2007; Uren and Price 2010; and Walker and  
81 Awange 2017).

82 In an effort to reap the benefits of interactive learning methods, and to address the perceived shortage of  
83 teaching hours for a relatively huge number of students in CVEN2000 (a civil engineering surveying) unit at  
84 Curtin University, Australia, two-hourly workshop sessions per week were introduced in 2009 (see, e.g., Anwar et  
85 al., 2012). The workshop sessions aimed at providing students with more hands on knowledge on theoretical and  
86 practical skills in surveying needed to undertake a well-planned project, and also to provide them with a series of  
87 industry-based skills such as teamwork and communication skills (e.g., Ellis et al., 2008; Webster, 2000; Vora and  
88 Markozy, 2011), cross-cultural interaction (e.g., Watson et al., 1993), and many others (as identified in e.g., Male  
89 et al. 2009).

90 In an earlier related study based on the 2012 survey of 67 students, Anwar et al., (2012) mapped workshop  
91 learning with Curtin's graduate attributes and found that most of the learning outcomes from workshop  
92 addressed Curtin's graduate attributes. In Anwar et al., (2013), based on the 2012 data, the workshop outcomes  
93 were assessed and found to enhance the development of fieldwork skills for Curtin students and to improve their

94 overall learning as field surveying engineers, making them ready for industry. The present study goes beyond  
95 those of Anwar et al., (2012, 2013) by providing a comprehensive analysis of the overall contribution of  
96 workshops in engineering surveying teaching and learning based on a two-year survey of 191 students in 2012  
97 and 155 students in 2013. The two main objectives of the study are (i) to assess the potential of workshop-based  
98 learning initiated in the Civil Engineering Drawing and Surveying (CVEN 2000) unit at Curtin in 2009 to  
99 enhance the students' achievement of industry-based skills such as teamwork and communication required by a  
100 graduate civil engineer, and (ii) assess the contribution of workshop-based learning to the students' overall  
101 learning of engineering surveying, a practical oriented unit. To achieve objective (i), a set of questionnaires were  
102 collected for the years 2012 and 2013 and analysed using statistical methods; correlation, percentage frequency  
103 distribution, and the principal component analysis (PCA).The findings of the questionnaire were complemented  
104 by the students' performances in both fieldwork and written examinations from 2009 to 2013, as well as  
105 qualitative data from Curtin University's eVALUate system (<http://evaluate.curtin.edu.au/>) from 2012 to 2013.

106

107 The study is organised as follows; first, the workshop learning experience at Curtin University is presented in  
108 detail starting with a background of the Civil Engineering Drawing and Surveying (CVEN 2000)unit, where  
109 engineering surveying is taught. This is followed by the contents, aims, and teaching of the workshops. Data  
110 collection, analysis methods and the results are then discussed before concluding the study.

## 111 **Workshop learning experience**

### 112 Background

113 Engineering surveying is the branch of surveying course normally taught to civil engineers and mine engineers  
114 (Walker and Awange 2017), and architectures in most universities worldwide, and is used extensively in building  
115 and construction, where angles, distances, and heights are required in the design and construction of civil  
116 engineering projects (see e.g., Uhren and Price 2010). In most universities, it is normally taught as a stand-alone  
117 unit for the entire semester with the aim of equipping graduate students with the skills needed to plan and design  
118 engineering projects, all which requires that students have knowledge and understanding of the surveying  
119 techniques and the associated instruments (Schoefield and Breach 2007; Uhren and Price 2010; Walker and  
120 Awange 2017).

121 At Curtin University (Australia), engineering surveying unit is offered as a sub-unit of Civil Engineering Drawing  
122 and Surveying (CVEN 2000)(previously known as Civil Engineering Methods 267) in the second year of study  
123 and comprises 1-hour lecture, 2-hours workshop and 2-hours fieldwork per week. Curtin University is  
124 committed to producing graduates who demonstrate the following graduate attributes: (i) applying discipline  
125 knowledge, (ii) thinking skills, (iii) information skills, (iv) communication skills, (v) technology skills, (vi) learning  
126 how to learn, (vii) international perspective, (viii) cultural understanding and (ix) professional skills (Graduate

127 Attributes Policy, 2006; Anwar et al. 2012). To realize these attributes, CVEN 2000 unit is designed to achieve  
128 the following unit learning outcomes (ULOs, i.e., what is expected of a student following a successful  
129 completion of the unit at Curtin University): (1) Interpret Civil Engineering drawings, including the use of plans,  
130 elevations, sections and details for structures, roads and drainages (2) produce drawings using CAD software (3)  
131 apply the theory and practice of surveying instruments as applied to civil engineering and construction projects  
132 (4) explain and apply related calculations and surveying techniques, and (5) describe the theory and practice of  
133 surveying instruments related to civil engineering and construction projects. Fieldworks assess the learning  
134 outcomes 3 and 4 and comprise 20% of the total marks while the examination assesses ULOs 3, 4 and 5, and  
135 comprise 30% of the marks (i.e., a total of 50% for the combined practical and exam marks from the surveying  
136 part of the unit). Of the 20% allocated for the surveying fieldwork, the students are expected to do three  
137 fieldwork worth 90 marks (i.e., 25 marks each for assessment 1 and 2, and 40 marks for assessment 3). Each  
138 assessment was first converted to a percentage, which was ultimately scaled to a final score of 20 marks. The  
139 remaining 50% of the marks comes from the drawing component of the unit and assesses unit learning  
140 outcomes 1 and 2.

#### 141 Workshops: Aims, Contents and Teaching

142 To achieve ULOs 3, 4 and 5, civil engineering surveying students were required to carry out four assessed  
143 practicals; two of which were individual-based submissions, while the other two were group-based submissions.  
144 The workshops, (2hr duration) were aimed at (i) providing an in-depth exposition of the unit materials covered  
145 during the 1-hour lecture, (ii) instructing step-by-step four practical sessions, and (iii) enhancing students' critical  
146 thinking and computational skills through individual hands-on training. Two workshops per week were  
147 organized, with each workshop consisting of approximately 60 students, with two lecturers in charge. From an  
148 approximately 200 total number of students, each student was required to attend all the 6 workshops, where  
149 five were tailored towards the fieldwork while the remaining one focused on exam preparations.

150 The contents of the workshops were designed in such a manner that workshop 1 introduced spirit levelling as a  
151 survey technique for height measurements. In this workshop, students were introduced to field techniques,  
152 which demonstrated procedures for unpacking, setting-up, operating, and repacking levelling instruments. This  
153 workshop enabled students to use the Automatic Level instrument to undertake the first practical designed for  
154 the establishment of the vertical control. Workshop 2 followed on the first one by generating a digital terrain  
155 model (DTM) using the data collected from the first practical. During workshop 2, students were helped to  
156 understand the specifications of design surface parameters for vertical profiles of, e.g., roads or sewer lines.  
157 Workshop 3 was geared towards the establishment of the horizontal control and similar to workshop 1,  
158 introduced the students to traversing, a procedure for establishing of horizontal controls using angular and  
159 distance measurements using the Total Station instrument. Workshop 4 then presented and demonstrated the  
160 use of Bowditch method to reduce traverse field observations. Having gathered the theoretical and practical skills  
161 from the four workshops, Workshop 5 then prepared the students for their fieldwork examination that required

162 them to set out horizontal curves using Total Stations (introduced in workshop 3) and handheld GPS receivers.  
163 Each student was given a section of the horizontal curve and asked to calculate the setting out parameters in  
164 order to develop his/her computational skill. Two lecturers present during the workshops offered help to the  
165 students during their individual calculations, moderating group discussions, and discussing potential field-related  
166 problems. Once the students understood how to calculate the setting out parameters of the horizontal curve,  
167 each group (of four) was given the parameters of a horizontal curve to set out during the fieldwork without the  
168 lecturer/tutors help. Once the students completed setting out the horizontal curve, they were assessed in the  
169 field where the assessment score was marked out 30, while the individual calculations were marked out of 10. A  
170 student's overall score in this assessment was therefore, 40 marks, i.e., 16% of the total marks of the CVEN 2000  
171 unit. Since it was a group-based submission, the students were expected to work as a team, employing their  
172 critical thinking skills to set out the curve and also employ their communication skills within their group in order  
173 to complete the task to specification and in a timely manner. As already mentioned, all these virtues were  
174 emphasized during the fifth workshop, and as such, during the actual field examination, the lecturers did not give  
175 the students any help but expected them to make use of the workshop-based learning experience. Finally, the  
176 remaining sixth workshop was dedicated towards preparing the students for the exam as elaborated in (4) below  
177 (see Figure 1).

178

179 To achieve the aims of the workshops discussed above, the following tasks and activities were carried out during  
180 the workshops (examples are given for illustration purposes only):

181 1. During the workshop, first, a quick overview (about 10 minutes) of the materials covered during the 1-  
182 hour lecture was presented, followed by a demonstration of the required computational skills required to  
183 solve the fieldwork related problems for that week. No software tools were allowed during the  
184 workshops but rather, the emphasis was on manual computation in-order for the students to develop  
185 computational and critical thinking skills. For example, to adjust and correct angle and distance  
186 measurements, the students were introduced to the Bowditch's method. The lecturer demonstrated on  
187 the whiteboard all the computational steps required starting from measurements to deriving the final  
188 coordinates. Once this demonstration had been done and discussed with the students, a similar  
189 computational task was given to the students to solve individually. Two lecturers monitor their  
190 computational skills and helped them where necessary. One of the students was asked to demonstrate  
191 the solution on the whiteboard followed by a discussion by the rest of the students. In case of more  
192 complicated problems, the lecturer demonstrated the solution on the board. Besides just introducing  
193 students to solving problems and instructions given as is often done in traditional tutorial mode of  
194 learning, the workshops went way beyond the traditional tutorials by not only *incorporating components (2)*  
195 *and (3)* below, but also by demonstrating both field procedures and computational steps required to

196 process the observations, encouraging group-based discussions, and expounding on individual-based  
197 tasks.

198 2. In the last 30 minutes of the workshop, students were introduced to the aims and practical aspects of  
199 the fieldwork for that week. The field works were designed such that the students were able to apply  
200 their knowledge gathered from (1). For example, if the practical task required designing of a cycling  
201 path, students were expected to know how heights (known as reduced levels (RL)) were measured and  
202 used to draw the longitudinal and cross-sectional profiles, derive the formation (design) heights, and  
203 compute areas and volumes of earthworks. The computational skills obtained in (1) were thus used to  
204 employ critical thinking when calculating the design parameters of a given problem (see, e.g., Snyder and  
205 Snyder 2008; Walker and Awange 2017). In addition, the students were introduced to the relevant  
206 instruments, e.g., Total Station, and the preliminary handling techniques given.

207 3. In order to demonstrate computational, critical thinking, and instrument handling skills obtained in (1)  
208 and (2), the last fieldwork was conducted as a practical examination. However, one of the objectives of  
209 fieldwork was also to enable students acquire teamwork skills as Engineers Australia's Graduate  
210 Attributes emphasize the ability of graduate engineers to work in high performance teams (e.g., Anwar et  
211 al. 2012). Students carried out the tasks in a team but made their calculations both individually and in  
212 groups as already discussed. In order to develop teamwork skills, for example, the students were given  
213 parameters of a centreline to be set out during their fieldwork. In workshop 5, they discussed the  
214 procedures for setting out this curve in the field and distributed the tasks amongst themselves (i.e.,  
215 entirely managed the work by themselves). For each team, during the workshop, the lecturers explained  
216 how best to exploit team spirit to achieve the desired outcome. Examples of photos of previous  
217 students working as a team were presented to motivate them. The workshop emphasised on the need  
218 for students to communicate amongst themselves in order to complete the task within the stipulated  
219 time and specification. From the assessment point of view, pre-defined standardized rubrics were given  
220 to each group showing how the marks were allocated for various tasks, some of which assessed the  
221 students' communication and teamwork skills. For example, the rubric specified the marks allocated for  
222 setting up the instrument (i.e., centering and orientation of the instrument, levelling circular bubble, and  
223 levelling plate bubble), a task that require teamwork. Furthermore, students had to communicate  
224 amongst themselves on how best to set out pegs at given radius. This required a well-thought strategy  
225 and clear communication through handsets and proper use of sign languages. Proper communication  
226 and teamwork scored high marks as specified in the rubric. Both verbal and written feedbacks were  
227 provided for both individual and teamwork skills during the field.

228 4. The last workshop was intended to revise the syllabus and prepare the students for the exams. Students  
229 were given questions that assessed their computational skills and abilities to think critically. The model  
230 questions covered the computational and necessary skills obtained in the previous workshops, lectures,



231 and the activities carried out in fieldwork. The students were then given 1-hour to solve the two  
232 problems individually. In the remaining hour, the solutions were discussed thereby providing the  
233 students with an opportunity for self-assessment and an opportunity to apply the knowledge of  
234 mathematics, science and engineering.

235 **Figure 1**

## 236 **Methodology**

### 237 Data collection

238 To achieve the first objective of the study, i.e., to investigate if the students' industry-based skills were enhanced  
239 through the workshops introduced in 2009, an anonymous questionnaire survey was conducted for all the  
240 students who took part in the workshops in CVEN2000 unit in 2012 (191 students) and 2013 (160 students)  
241 respectively. To validate the survey, both face validation (i.e., discussing with students who previously undertook  
242 the course) and content validation (i.e., having experts in the field review the questionnaire's contents) were  
243 adopted (see, e.g., OMB 2002). Face validity was aimed at determining whether the questions addressing the  
244 workshop learning contributed towards the students' industry-based skills development, and overall learning of  
245 surveying. The content validation aimed at assessing whether the survey fully captured and represented the  
246 concept that the workshop learning enhanced the achievement of necessary surveying engineering skills. To  
247 address the face validation, a group of 8 students who undertook the CVEN2000 unit in 2011 was randomly  
248 selected and the draft questionnaire was given to them for review. The students read the questions and put their  
249 agreement or disagreement in understanding the purpose of the survey, and also commented on whether the  
250 questions were clear or unambiguous. The suggestions obtained from the students were used to modify the  
251 questions until all the participants came to an agreement that the final modified questions were clear,  
252 unambiguous and captured the intended purpose.

253 Content validation then followed by having the outcome of the face validation above subjected to peer review by  
254 colleagues who were experts in the subject. The final questionnaire (i.e., the outcome of both face and content  
255 validation above) was then reviewed by the Dean of Teaching and Learning at Curtin University, and then sent  
256 to the ethics committee for approval. The approved set of questionnaire is presented in Table 1. These  
257 questionnaires were distributed to the students during the last (sixth) workshop. The last workshop was  
258 dedicated towards the exam preparation and it was likely to attract a maximum number of students, although it  
259 could be equally counterproductive since students could be busy with their final assignments that needed to be  
260 submitted during the same week. Nonetheless, the survey was conducted anonymously and the feedback method  
261 was similar to Curtin's online unit eVALUate system such as, "Strongly Agree-SA", "Agree-A", "Strongly  
262 Disagree-SD", "Disagree-DA and "Unable to Judge-UJ" (e.g., <http://evaluate.curtin.edu.au/>). Out of 351  
263 students in 2012 and 2013, 67 in 2012 and 93 in 2013 students responded to the survey, giving a 46% response

264 rate, which is above the Curtin University's 35% target rate in its eVALUate system. The higher response in 2013  
265 compared to 2012 could be attributed to the fact that those students who attended the workshops in 2012 might  
266 have recommended the workshop to their 2013 friends. The data is analysed using techniques discussed later.

267

268

**Table 1**

269 To evaluate whether the workshops enhanced the students overall learning of engineering surveying, i.e.,  
270 objective (i) and to some extent objective (ii), the 2012 and 2013 practical and examination results were also  
271 analysed together with the qualitative data from Curtin's eVALUate (<http://evaluate.curtin.edu.au/>). Curtin's  
272 eVALUate system provides students with the opportunity to provide feedback on selected items on a scale:  
273 "Strongly Agree-SA", "Agree-A", "Strongly Disagree-SD", "Disagree-DA and "Unable to Judge-UJ". Besides  
274 these, they are also provided with the opportunity to express the most helpful aspects that enhanced their  
275 learning as well as how the unit could be improved. In this study, these qualitative data were considered to  
276 further decipher on the effect of workshops on students' overall learning of surveying.

277 Data Analysis

278 Confidence Interval Estimation

279 In this study we analysed and compared the performance of the students between 2012 and 2013 based on the  
280 questionnaire survey data collected as discussed in the preceding paragraph. Since only 46% of the students  
281 responded to the survey, it was necessary to validate whether the survey results represented the total number of  
282 enrolments. To analyse this representation for both the years (2012 and 2013), confidence interval estimation  
283 was carried out for the proportion, considering the total number of students enrolled to be finite. Confidence  
284 limit is a standard measure of accuracy of the results in a statistical analysis and is derived by first dividing the  
285 data into subsections and obtaining the mean. The confidence limit is then defined as a range of standard  
286 deviations from the mean (Huang et al., 2003). It is computed as (Heeringa et al., 2010):

287

288

$$p_{agree, N} = p_{agree, n} \pm Z \sqrt{\frac{p_{agree, n}(1 - p_{agree, n})}{n}} \sqrt{\frac{N - n}{N - 1}}, \quad 1)$$

289 where  $p_{agree, n}$  is the percentage of agreement for any attribute under consideration,  $n$  is the number of the  
290 students who responded to the questionnaire,  $N$  is the total number of the students enrolled in the unit,  $Z$   
291 depends on the confidence level required, i.e., the value of  $Z$  becomes 1.96 for 95% confidence level. The  
292 confidence limits for the students enrolled are given by  $p_{agree, N}$ . The advantage of the confidence interval  
293 approach is that it provides an interval that reveals the uncertainty of the estimated value (i.e., the mean) as  
294 opposed to point estimation of the mean which produces only single values. The drawback of the approach is  
295 that its interpretation is not trivial since it does not take into consideration any prior information on the  
296 population mean.

297

## 298 Frequency Percentage Analysis

299 The questionnaire data aimed at achieving objective (i) was analysed using the statistical frequency percentage  
300 method. In this approach, the total number of responses (Tr) per question item given in Table 1 was identified.  
301 Within each item, the total number of responses to the criterion, i.e., SA, A, SD, D and UJ is then divided by the  
302 total number of responses per questionnaire item (Table 1) and multiplied by 100 to give the equivalent  
303 percentages, which are plotted as bar graphs (see e.g., Figure 2). For the SA criteria for example, the process of  
304 creating a percentage frequency distribution involved first identifying the total number of students who  
305 responded to a questionnaire item (Tr), then counting the total number of students who chose SA for that  
306 questionnaire item (TSA) and then dividing and multiplying by 100 (e.g., TSA/Tr x 100). Details on the method  
307 and its limitation are presented, e.g., in Heiman (2011). Whereas this was done for each criterion item as shown  
308 in Figure 2, a more representative value of agreement was obtained by combining Agree (A) and Strongly Agree  
309 (SA) criteria to give the percentage of agreement shown in Figure 3, i.e., (% agreement=(A+SA)/Tr x 100). The  
310 advantage of percentage frequency distribution is that it provides visual displays that organise and present  
311 frequency data in a manner that is easier to interpret and compare data sets. However, this method may not  
312 provide a rigorous statistical approach for comparing specific characteristics of distributions such as the means  
313 and standard deviations.

314

## 315 Correlation Analysis

316 The feedback from the participants was analysed for the dependence of one or more attributes to the other  
317 remaining attributes. This dependence between the attributes was statistically analysed with the help of  
318 correlation analysis. Correlation analysis based on the statistical method of the principal component analysis  
319 (PCA) is discussed next. The advantage of the correlation analysis is that it provides the relationship between  
320 variables. The correlation analysis was carried out based on the Pearson's product moment coefficient (r):

$$321 \quad r = \frac{n \sum xy - \sum x \sum y}{\sqrt{n \sum x^2 - (\sum x)^2} \sqrt{n \sum y^2 - (\sum y)^2}} \quad 2)$$

322 where the correlation coefficient (r) is computed between two attributes (x,y) for n number of respondents  
323 considered in this study. The correlation values obtained in Eq. 2 was tested for their significance using a simple  
324 Students *t-test* by calculating a test statistic (t):

$$325 \quad t = \frac{r}{\sqrt{(1-r^2)/(n-2)}} \quad 3)$$

326 Based on the calculated value of t, a p-value is determined from a t-distribution with n-2 degrees of freedom. If  
327 the p-value is less than 0.05 (i.e., at 95% confidence level), it indicates that there exists significant relationship  
328 between the two learning attributes. For example, students who had good instrumental knowledge tended to

329 perform relatively better at fieldwork while those who possessed high critical thinking skills tended to handle  
330 unseen problems better in the fieldwork.

### 331 Principal Component Analysis (PCA)

332 Principal Component Analysis (PCA) is a variable reduction procedure, which is useful in extracting the main  
333 variance of datasets. In the context of a questionnaire survey, it may be expected that a pair of highly correlated  
334 attributes serve more or less the same purpose, thus there is a need for excluding some of them or combining  
335 them for further analysis or evaluation. The PCA method used here was based on eigenvalue decomposition of  
336 the data-derived auto-covariance matrix. The retained components serve as the dominant satisfactory factors,  
337 while those excluded most often correspond to the lower correlation with the overall score. Note that it is  
338 common in qualitative researches to use statistical approaches (e.g., Cronbach's alpha) for evaluating the internal  
339 consistency of the designed questions. In this study, however, such approach was not used since it was felt that  
340 the questions were designed based on Curtin's eVALUate program (<http://evaluate.curtin.edu.au/>) and adequate  
341 validation process was used as discussed earlier.

342 To prepare the data for PCA, we first entered the values of 2012 and 2013 in a matrix  $X$  with separate columns  
343 for each variable to ensure that each row corresponded to the responses from one attribute. Missing data values  
344 in each column were filled by the mean of the corresponding column. Since the number of missing values was  
345 minimal, the impact of data filling was negligible. Before implementing PCA, each column was sorted with  
346 respect to the magnitude of the scores from 5 (the most satisfactory) to 1 (the less satisfactory). The PCA  
347 method thus enabled the analysis of the combined 2012 and 2013 data sets together rather than done separately  
348 as performed by the other methods discussed above. The data matrix  $X$  was decomposed by PCA as

$$349 \quad X = \bar{P}_k E_k^T, \quad 4)$$

350 where  $\bar{P}$  contains normalized principal components (PCs), and the columns of  $E$  contains the corresponding  
351 orthogonal eigenvectors known as empirical orthogonal functions (EOFs) see, e.g., Jolliffe (1986). The advantage  
352 of PCA is that one does not require a priori information of the underlying distribution of the sample collected.  
353 The drawback of the method, however, is that even when the underlying features of a system are known, they  
354 cannot be incorporated into a parametric model. North et al. (1982)'s rule of thumb was used to decide on the  
355 number of the dominant components (the subindex  $k$  in Equation 4) retained for the final interpretation.

### 356 Examination and eVALUate analysis

357 Investigating whether the workshop-based learning method actually enhanced the students' overall learning of  
358 engineering surveying i.e., objective (ii) was performed through the analysis of the students' academic record for  
359 the respective years (e.g., examination and field practical results) for the period 2009-2013. Such analysis is based  
360 on the fact that students attended the workshops prior to their introduction in 2009. The number of the students  
361 who attended the workshops, however, varied from year to year (but has been above 80% in all years).

362 Furthermore, it should be pointed out that the exam questions were not similar over the years and their  
363 complexity varied. Nonetheless, the exam questions and field practicals assessed similar outcome each year, e.g.,  
364 whether the students were able to undertake a levelling exercise (exam assessment) and to provide vertical  
365 controls and longitudinal and cross-sectional profiles (fieldwork assessment). It is therefore, sufficient to assume  
366 that based on the more than 80% attendance of the workshops and given that the exams and practicals both  
367 assessed similar outcomes each year, their analysis to infer on the impact of the workshops on the students'  
368 learning could be justified. The analysis results should, however, be interpreted with caution as the students  
369 performances may have varied depending on other factors such as the complexity of the exam questions and the  
370 students' state of mind during the exam.

371 The analysis is achieved by considering the number of students who scored over 50% in a given year in each  
372 component, i.e., 50% in the practical as well as 50% in the examination, and also in the final marks (combined  
373 practicals and examination). The practicals constituted 40% of the final marks while the written examination  
374 constituted 60%. This threshold was chosen since the students needed to score 50% or more in the unit to pass.  
375 In addition, a task of setting out horizontal curves in the field was assigned to each group of four students.  
376 Within this group, as explained earlier, each student was given a set of design parameters for a portion of the  
377 horizontal curve and was asked to compute the setting out parameters of the curve. This provided an assessment  
378 of the student's understanding of the task that was explained during the workshop. This was then followed by  
379 setting out of the center line of the portion of the horizontal curve as a group. The whole task required group  
380 teamwork and communication skills on the one hand, and critical thinking and problem solving skills on the  
381 other hand in order to best set out the curve to the required specification. Through this task, the performance of  
382 the students in the field practical enabled the evaluation of the role played by the workshops in enhancing the  
383 students' teamwork, communication, problem solving, and critical thinking skills.

384 To comprehend the findings of this study, an analysis of the post workshop qualitative data from Curtin's  
385 eVALUate system was also carried out to evaluate objective (ii). To analyse the qualitative data from Curtin's  
386 eVALUate system where the students were asked to comment on the most helpful aspects of Civil Engineering  
387 Drawing and Surveying (CVEN2000) unit, qualitative data for statements that mentioned workshop as having  
388 enhanced their learning in one way or another, e.g., the "*workshops were very helpful*", "*Workshop is a great place to ask  
389 doubts from lecturers and most of the problems are solved with the help of lecturers*", "*the workshops for the surveying. Made all the  
390 tasks and methods for evaluating data very clear*", etc., from the 2012 and 2013 data were counted. The total number of  
391 these comments was then divided by the total number of qualitative responses and multiplied by 100 to obtain a  
392 percentage value. This was repeated for those aspects the students thought could be improved in the unit. In  
393 2012, out of all the 89 responses (cf. 61 in 2013), 65 responded (cf. 41 in 2013) to the positive aspects of the unit  
394 while 58 (cf. 53 in 2013) to those aspects that they thought could be improved. The advantage of eVALUate  
395 system is that the data is directly obtainable online from the university system in graphic form and does not need  
396 further processing, and also the fact that the students can complete the questionnaire at their own time makes it

397 more attractive. However, the number of responses were found to be normally low and often attracts extreme  
398 (e.g., happy students and unhappy students will generally tend to be the respondent)responses.

399

## 400 **Results and Discussions**

401 Enhancement of industry-based desired skills.

### 402 *Confidence limit analysis*

403 Compared to 2012, the number of students enrolled in engineering surveying unit reduced in 2013 from 191  
404 (2012) to 160 (2013). However, in 2013 majority (93 out of 160) of the students responded to the survey  
405 anonymously compared to 63 out of 191 in 2012. The confidence limit for 15 questionnaire items shown in  
406 Table 2 was assessed to test if the survey represented the overall student population. From Table 2, it can be  
407 seen that the lower confidence limit increased in 2013 for most items, probably due to the higher number of  
408 responses received compared to 2012. The lowest confidence limit is seen for ‘handling unseen problems’ and  
409 ‘communication skills’ in 2012 and 2013 respectively. The lower and upper confidence limit increased by 24%  
410 and 9%, respectively, in 2013 (compared to 2012) for “handle unseen problems” and 20% and 7% for  
411 “communication skills”.The higher number of responses in 2013 could be attributed to the increased number of  
412 students attending the workshop. In the 2012 survey, 93.4% of the students had indicated that they would  
413 recommend the workshops to their friends and 99% of them indicated the same in 2013, thus indicating that  
414 these workshop sessions were gaining popularity with students as those participants inform their friends of the  
415 potential benefits to the learning outcome of the unit.

416

### **Table 2**

### 417 *Frequency Analysis Results*

418 The overall response of the participants for 2013 is presented in Figure 2 (those of 2012 are not shown). In  
419 general, it is observed that workshops have helped in enhancing the students’ learning skills in almost all aspects  
420 except in ‘communication skills’ and ‘handle unseen problems’, which recorded slightly higher disagreement  
421 (Figure 2). The frequency percentile results of questionnaire survey items (Table 1) based on the feedback of 67  
422 students out of 191 students in 2012 and 93 out of 160 in 2013 are summarized in Table 2 and Figure 3. The  
423 frequency percentile method was applied for all the items in the survey questionnaire (see, e.g., Heiman, 2011 for  
424 discussions on the procedure). The values shown in Figure 3 indicate the percentage of the combined students  
425 who chose Agree (A) and Strongly Agree (SA) to the questionnaire items. The 2012 results (Figure 3) revealed  
426 the students’ perception that skills relating to ‘correlate theory (97%)’, ‘instrument knowledge (89.6%)’, and  
427 ‘critical thinking skills (91.1%)’ were well achieved. Based on the students’ feedback of 2012, the class size of the  
428 workshops were reduced in 2013 by adding an extra 2-hour workshop per week leading to three 2-hour

429 workshops per week rather than two as was the case in 2012. This provided more flexibility for students to  
430 balance their working hours and the need to attend the workshops. As mentioned earlier, the 2012 group also  
431 indicated the possibility of recommending the workshops to their friends. This additional workshop time and the  
432 recommendation of the 2012 group to their friends resulted in increased attendance in 2013. This can be  
433 reflected in improved number of respondents (67 in 2012 and 93 in 2013) and also in increased scores, i.e.,  
434 ‘correlate theory (97.9%)’, ‘critical thinking skills (93.6%)’, as well as for other items listed in Table 2. As argued  
435 by Tek-Yew (2012), several methods could be adopted in order to enhance students’ “critical thinking” (see, e.g.,  
436 Snyder and Snyder 2008), a fact supported by this study, based on the students’ perception that critical thinking  
437 skills can be achieved not only through teaching but also through other development methods (Jawarneh et al.,  
438 2008; Khasawneh, 2004) such as workshops.

439 In 2012, “communication skills” received 68.7% of the overall students’ agreement. This relatively low  
440 agreement indicated that the workshop learning process needed further development of communication skills. In  
441 2013, some improvements were made in providing students’ feedback and encouraging communications during  
442 the workshops and the fieldwork. It was observed that during the fieldwork, students tended to group  
443 themselves based their ethnicity and culture (i.e., Asian students tended to group together). During the 2013  
444 workshops, students were encouraged to intermingle within the groups as they discussed how to tackle a given  
445 field problem. In the 2013 survey, therefore, communication skills showed improvement by receiving 77.2% of  
446 the students’ agreement, which although is remarkable (i.e., 12.4% increase from 2012), is still relatively low  
447 compared to the other surveyed items (see Table 2). This relatively low agreement indicates that the workshop  
448 learning process still needs further development on communication skills. Another survey item that showed a  
449 relatively low score in the 2012 survey that needed improvement was ‘handling problems during the fieldwork’  
450 (i.e., with only 67.2% of students’ agreement). In the 2013 workshops, discussing the potential field problems  
451 and presenting students with solutions before they undertook their fieldwork made improvements. For example,  
452 students were informed that when setting out horizontal curves in the field, one of the main problems is usually  
453 the confusion between the centerline and tangent points of the curve. Students were thus advised on how to  
454 avoid this confusion through checking out of the curve’s radius during the 30 minutes field demonstration (see  
455 item 2 under Workshops: Aim, Contents and Teaching above). It should be pointed out that such information  
456 could be delivered not necessarily in the workshop but also during the lecture. However, as pointed out earlier,  
457 the lecture time was only 1 hour and not all unseen problems could be addressed during that short period of  
458 time. Following such improvements, handling field problems scored 77.4% of the students’ agreement in 2013.  
459 This is still relatively low compared to other items, indicating a need of further attention in future workshops. In  
460 general, the overall students’ satisfaction based on frequency distribution analysis increased from 97% in 2012 to  
461 97.9% in 2013.

462 The workshops were also seen to assist students in their assignments, with over 90% of students in 2013  
463 agreeing that the workshop helped them in both their individual as well as group assignments. This is not a  
464 surprise since a more informal workshop-based learning helps them to understand and relate their problem

465 solving skills to fieldwork tasks. Students also agreed that other factors such as the ‘duration of workshop’, ‘size  
466 of the class’ and ‘feedback from the workshop’ helped to contribute to their overall learning experience.  
467 Feedback from workshop thus increased by over 9.5% in 2013 showing that the number of students who  
468 answered the survey and that perceived the feedback as helpful increased in 2013 compared to 2012 survey.  
469 Nonetheless, this aspect still needs further improvement.

470 **Figure 2**

471 **Figure 3**

#### 472 *Correlation Results*

473 A simple correlation analysis (Eq 2) was carried out between the different learning attributes to assess how they  
474 relate to each other in learning. The results of the correlation analysis are provided in Table 3, where correlation  
475 coefficients greater than 0.5 are considered to be significant at 95% confidence level. From the 2012 results in  
476 Table 3, it can be seen that critical thinking and instrument knowledge indicates the strongest correlation  
477 coefficient (0.82), suggesting that the workshops could have contributed to enhancing the students’ critical  
478 thinking leading to a better handling the instruments during field practicals. This is supported by a correlation  
479 coefficient (0.63) between correlating theory and fieldwork, which clearly indicated that workshops helped  
480 students to think critically and obtain necessary skills to practice. Instrumental knowledge was found to directly  
481 translate to fieldwork with a correlation a coefficient of 0.52, while fieldworks tended to benefit individual  
482 assignments showing a correlation coefficient of 0.52 between them.

483 In the 2013 survey, the results of Table 3 indicated correlations of 0.6 between ‘field practical’ and ‘correlating  
484 theory’, 0.58 between ‘critical thinking’ and ‘instrument knowledge’, further suggesting that the workshops were  
485 able to help enhance fieldwork performances. A low correlation between ‘fieldwork’ and ‘handling unseen  
486 problems’ (i.e., 0.28 in 2012 and 0.33 in 2013) is understandable given that real world problems are often difficult  
487 and requires much more than what is usually taught in the class or discussed indoors. Fieldworks’ knowledge  
488 acquired during the workshops and actual undertaking of the field tasks seem to be contributing to ‘exam  
489 preparation’ as seen from correlations of more than 0.5 in both 2012 and 2013.

490 **Table 3**

#### 491 *PCA Results*

492 The results of PCA (Eq. 4) are summarised in Figure 4, which shows the first dominant component (EOF1 and  
493 PC1) corresponding to 90% of total variance retained based on the North et al., (1982)'s rule of thumb. EOF1  
494 (Figure 4a) indicated that “Correlate Theory” and “Exam Preparation” were the two dominant attributes in the



495 questionnaire, while “handle unseen problems”, and “communication skills” were the two items that have less  
496 correlations with the scores. PC1 (Figure 4b) indicated that 145 out of 160 (corresponding to 90%) responses  
497 have a magnitude of greater than 3. The cross-correlation results (Figure 5), at 95% confidence level, showed  
498 that the dominant items: “correlate theory”, “critical thinking skills”, “handle unseen problems”, “feedback on  
499 the workshop”, “group assignments”, and “overall satisfied” can be used to assess the benefit of the workshops  
500 (see Figure 5). They corroborate the results of Table 3. The motivation to apply the PCA method here is its  
501 capability to assess the items that are similar both in 2012 and 2013 workshops. The outcome of this test  
502 evaluates whether common items represent a consistent impact on engineering surveying learning, considering  
503 two independent groups in 2012 and 2013, and different workshop programs. The limitation of such assessment,  
504 however, was that the results were only representative for the items that were repeated in the 2013 workshop.

505  Figure 4

506  Figure 5

507 Enhancement of students’ overall learning.

#### 508 *Examination and eVALUate Results*

509 Independent of the questionnaire administered during the last workshop, investigation of whether workshop  
510 learning contributed towards enhancing the students’ overall learning of engineering surveying following their  
511 introduction in 2009 was done. To do so, the students’ performances both in the exams and fieldwork  
512 assignments from 2009 to 2013 were analysed. Figure 6 shows the possible impact of workshops on the overall  
513 students’ performance in the examinations and field practicals. The workshop learning and teaching materials in  
514 2009 was not fully developed since the workshops had just been introduced. Moreover, multiple tutors marked  
515 the fieldwork reports, which provided high marks in 2009 as can be seen from Figure 6. To the contrary, the  
516 performance in the exam part (30% of the unit) clearly revealed that the students’ performance was low  
517 compared to the fieldwork, as the pass rate in the exam was less than 20%. Overall, the pass rate was about 69%  
518 because of high marks obtained in the fieldwork reports. The data of 2009 thus serves as the baseline upon  
519 which fully developed workshops that started in 2010 onwards were compared. The pre-workshop data of 2008  
520 were also included to highlight the inconsistency that existed between fieldworks and exams.

521 These findings were taken into account and the workshop learning platforms were redesigned by putting  
522 appropriate learning resources and providing useful feedback with the objective to achieve Curtin’s learning  
523 outcomes. These are clearly reflected in the results of 2010-2013, indicating a slightly lower achievement in  
524 fieldwork. The students’ performance in the exams (closed book exams) however, increased by 3 times in 2010,  
525 potentially due to the new workshop learning platform. From 2010 onwards, more than 50% of the students  
526 achieved the desired pass mark (50%) of the examination. The overall students’ performances were also found to

527 slightly vary in different years because of the number of enrolled students. Since the number of students has  
528 been increasing continuously since 2009, lecturers face more challenges in assessing the fieldwork reports. It is  
529 critical to consider whether group submissions or individual submissions of a group work could provide  
530 sufficient learning outcomes. This issue will be reported in our forthcoming contribution. As to the possible  
531 impact of the workshops on the students who fail the unit, Figure 6 offers some insight. By comparing the  
532 fieldwork and the exam scores, it is seen that the scores of the field work tend to be higher than those of the  
533 written exams, implying that the workshops more than the examination tend to influence the practical aspects of  
534 the students who fail the unit. This deduction should however be interpreted cautiously as other factors such as  
535 the physical and emotional state of the students during the exam could influence the outcome. Besides, it is  
536 normal for students to have higher marks from their fieldwork relative to exam due to time constraint in the  
537 exam and as such, the failing aspect might not be a direct consequence of using workshops.

538 Comparing the performance of 2012 to that of 2013, the periods over which the survey was undertaken, it is  
539 seen that the overall performance improved in 2013. In the fieldwork, the performance increased from 74% in  
540 2012 to 91% in 2013. The exam performance also increased from 51% in 2012 to 70% in 2013. This remarkable  
541 improvement could be attributed to the fact that students' feedback from the 2012 survey were taken into  
542 consideration while undertaking the 2013 workshops. As stated earlier, the potential field problems were  
543 discussed during the workshops. Students were also encouraged to embrace multiculturalism and communication  
544 within their groups in order to handle potential field problems and communication skills effectively.

545 Finally, the qualitative analysis of the eVALUate results from 65 respondents in 2012 and 41 respondents in 2013  
546 data indicated that 61.2% and 70% of the students, respectively, found the workshops to be the most important  
547 component contributing to their learning skills of the CVEN2000 unit. This provides additional evidence of the  
548 workshops' contribution to enhancing the students' overall learning of engineering surveying besides the  
549 questionnaire surveys. The improvements from 2012 to 2013 by 13.8% could be attributed to the improvement  
550 made in the workshops following the feedbacks from 2012 survey. Of the 2012 and 2013 qualitative comments  
551 on what could be improved on the unit in the Curtin University's eVALUate data; there was no negative  
552 comment on the workshops requiring improvement. Comments on improving the workshops were thus  
553 obtained in the 2012 study questionnaire survey and utilized in the 2013 workshops.

554

### Figure 5

#### 555 *Enhancing Communication and Teamwork Skills*

556 To indicate if workshops enhanced the overall learning of engineering surveying and as well as the industry-  
557 based desired skills of communication and teamwork, the final fieldwork was a group assessment. The task  
558 involved setting out a horizontal curve using various surveying equipment (e.g., Total Stations, Tapes, and global  
559 positioning systems(GPS) receivers) with no help from the lecturers. Each group was given specific set of  
560 parameters (e.g., curve radius, deflection angle, formation width of the road, etc) for setting out a road centreline

561 using a hand-held GPS receiver. Intense communication, teamwork, and critical thinking skills were essential and  
562 necessary for a successful completion of the task.

563 For example, in the 2012 task of setting out horizontal curves, there were 182 students in the field practical. This  
564 task was marked out of 40 with the highest student scoring 40 while the least student obtained 15. The class  
565 average was 30, which support the argument that the students were able to link their critical thinking skills to  
566 instrument knowledge (i.e., correlation of 0.82; significant at 95% confidence level), communicate amongst  
567 themselves, and correlating theory to fieldwork (i.e., a correlation of 0.63). In 2013, out of 155 students assessed  
568 for a similar fieldwork marked out of 40, the highest student scored 40 while the least student obtained 10, with  
569 the class average being 31, thus further supporting the fact that workshops could have played a crucial role in  
570 enhancing the teaching and learning of engineering surveying (CVEN2000) unit at Curtin University. In  
571 particular, the most significant field observable practise was the manner in which students grouped themselves in  
572 mixed cultural backgrounds. In these groups, students were asked to discuss the practical challenges of setting  
573 out their horizontal curves in order to assess their communication skills, some of which could have been  
574 acquired in the workshops. As previously mentioned, a standardized marking rubric was given to all groups.

## 575 **Conclusion**

576 The workshops were designed in a way that provides scenarios reflecting tasks that could be reasonably expected  
577 out of an on-site junior civil engineer or a field surveyor, and were therefore, directly related to the fieldwork.  
578 The expectations were clearly enunciated, and the aims of the exercises were generally well understood. The  
579 results of this study revealed that the students were satisfied with the workshops and recognised that it  
580 contributed to developing the different learning attributes and, therefore, would recommend it to their friends.  
581 Workshops may be used as a good learning platform for civil engineering surveying unit, which often comprises  
582 of fieldworks. The workshops were found to enhance all engineering surveying industrial-based learning skills.  
583 From the frequency distribution analysis, most students agreed that workshops contribute to the first three items  
584 “correlate theory”, “critical thinking skills”, and ‘instrument knowledge’ in 2012. The drop in score for  
585 instrument knowledge from 96.6% to 85.9% in 2013 needs to be investigated further in order to improve in the  
586 future workshops. A relatively low agreement was found for “communication skills” and “handling problems”.  
587 The workshop learning mechanisms as a distributed learning tool will in future be improved to address these  
588 areas that received low agreements. Independently, the qualitative eVALUate data and the examination results  
589 showed that workshop is an important tool for enhancing the overall learning of engineering surveying, which  
590 help them prepare for workforce challenges that require strong teamwork, working within a multicultural  
591 society, and good communication skills. The workshop appears to have some impacts on these three attributes,  
592 as seen during the fieldwork assessment of setting out horizontal curves. In this assessment, students worked in  
593 groups to undertake the setting out task, which required them to communicate among members of different  
594 ethnic backgrounds to undertake the task. Furthermore, it is worth pointing out that the success of the

595 workshops motivated similar introduction in Mine Surveying and GIS (for Mine Engineering degree) and  
596 Satellite Positioning for Mining units (for Mine and Engineering Surveying degree) at Curtin University. Finally,  
597 we point out that the results should be interpreted with caution since the analysis presented here was limited to  
598 only few years of data. Nonetheless, the results of the study highlight the benefits of having workshops to  
599 supplement the teaching of engineering surveying.

600

#### 601 **Acknowledgements**

602 Authors would like to acknowledge the financial support provided by the Faculty of Science and Engineering at  
603 Curtin University under the Scholarship of Teaching and Learning (Project No. SMEC-101-11). The authors also  
604 would like to thank the reviewers for their valuable comments on the paper.

605

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607 **References**

- 608 Adair, J. K., Reyes, M. A., Anderson-Rowland, M. R. and Kouris, D. A. (2001). Workshops vs. tutoring: How  
609 ASU's minority engineering program is changing the way engineering students learn. *Frontiers in Education*  
610 *Conference*, 2001. 31st Annual, Vol (2). DOI: 10.1109/FIE.2001.963659  
611
- 612 Anwar, A. H. M. F., Awange, J., Arora, B, Nikraz, H., and Walker, J. (2012). Mapping workshop learning to  
613 graduate attributes for Civil Engineering surveying, In *Proc. of AAEE Conf.*, Melbourne, Dec 3-5.
- 614 Anwar, A. H. M. F., Awange, J. L., Hamid, N., and Forootan, E. (2013). Learning surveying and developing  
615 fieldwork skills through workshop. *Proceedings of the 24th Annual Conference of the Australasian Association*  
616 *for Engineering Education AAEE2013*.
- 617 Baroffio, A., Nendaz, M. R., Perrier, A., Layat, C., Vermeulen, B. and Vu, N. V. (2006). Effect of teaching context  
618 and tutor workshop on tutorial skills. *Medical Teacher*, 28 (4), pp. 112-119, Informal UK Ltd UK  
619 (<http://www.ncbi.nlm.nih.gov/pubmed/16807161>).
- 620 Bartle, E. K., Dook, J. and Mocerino, M. (2011). Attitudes of tertiary students towards a group project in a  
621 science unit. *Chemistry Education Research and Practice*, 12: 303-311. DOI: 10.1039/C1RP90037D.
- 622 Bourner, T. and Flowers, S. (1997). Teaching and learning methods in higher education: A glimpse of the future.  
623 *Reflections on Higher Education*, 9: 77-102. DOI: 10.1.1.117.6294
- 624 Campbell, D., Dawes, L., Beck, H., Wallace, S., Boman, M., & Reidsema, C. (2009). Graduate attribute mapping  
625 with the extended CDIO framework. *In Proc of AAEE Annual Conference*, Adelaide, 599-604.  
626
- 627 Davis, D., O'Brien, M.A.T., Freemantle, N., Mazmanian, P., and Taylor-Vaisey A. (1999) Impact of formal  
628 continuing medical education. Do conferences, workshops, rounds, and other traditional continuing educational  
629 activities change physical behaviour or health care outcomes? *282 (9): 867-874*.
- 630
- 631 Dori, Y. J. (2005) How does technology-enabled active learning affect undergraduate students' understanding of  
632 electromagnetism concepts? *The Journal of the Learning Sciences 14(2): 243-279*  
633
- 634 Ellis, R. A., Goodyear, P., Calvo, R. A. and Prosser, M. (2008). Engineering students' conceptions of and  
635 approaches to learning through discussions in face-to-face and online contexts. *Learning and Instruction 18(3):*  
636 *267-282*.
- 637 Felder, R. and Brent, R. (2003). Designing and teaching courses to satisfy the ABET Engineering criteria. *Journal*  
638 *of Engineering Education 92(1), 7-25*.
- 639 Fernandez-Samaca, L. and Ramirez, J.M. (2010). An approach to applying Project-Based Learning in engineering  
640 courses. *IEEE*, pp.1-6, 15-17 Sept. 2010. DOI: 10.1109/ANDESCON.2010.5630007.

641 Fullilove, R.E and Treisman, P. U (1990) Education mathematics achievement among African American  
642 undergraduates at the University of California, Berkeley: An evaluation of the Mathematics Workshop Program.  
643 The Journal of Negro Education, Vol. 59, No. 3, pp. 463-478  
644

645 Graduate Attributes Policy, (2006). Curtin, Australia.  
646 Heeringa, S. G., West B. T. and Berglund P. A.(2010). Applied survey data analysis. Boca Raton: Chapman &  
647 Hall/CRC, ISBN: 978-1-4200806-6-7

648 Heiman, G. W. (2011). Basic statistics for the behavioural sciences.Sixth Edition.Wadsworth Gengage Learning,  
649 Belmont USA.

650 Huang, N. E., Wu, M., Long, S. R., Shen, S. S., Qu, W., Gloersen P. and Fan K. (2003).A confidence limit for the  
651 empirical mode decomposition and Hilbert spectral analysis. Proc. R. Soc. Lond. A 2003 459, 2317-2345, DOI:  
652 10.1098/rspa.2003.1123

653 Jawarneh, M., Iyadat, W., Al-Shudaifat, S. andKhasawneh, L. (2008).Developing critical thinking skills of  
654 secondary students in Jordan utilizing Monro and Slater strategy, and McFarland strategy. International Journal  
655 of Applied Educational Studies 3 (1): 82-91.

656 Jolliffe, I. T. (1986). Principal Component Analysis. Springer-Verlag, pp. 487. DOI: 10.1007/b98835. ISBN 978-  
657 0-387-95442-4.

658 Khasawneh, R. (2004).Developing history course for tenth-grade in light of basic learning standards and testing  
659 the effectiveness of scientific unit in students' gains and improving critical thinking.Unpublished Doctoral  
660 dissertation, Yarmouk University, Jordan.

661 Kilminster, S., Hale, C., Lascelles, M., Morris, P., Roberts, T., Stark, P., Sowter, J. andThistlethwaite, J. (2004).  
662 Learning for real life: Patient focused interprofessional workshops offer added value. Medical Education 38:  
663 717–726. Doi: 10.1046/j.1365-2923.2004.01769.x.

664 Laws, P. W. (1991) Calculus-based Physics without lectures. Physics Today 44: 24-31.

665 Male, S. A., Bush, M. B., and Chapman, E. S. (2009).Identification of competencies required by engineers  
666 graduating in Australia. 20th Annual Conference for the Australasian Association for Engineering Education, 6-9  
667 December 2009: Engineering the Curriculum.

668 Mills, J. and Barber, D. (2004).Geomatics Techniques for Structural Surveying,Journal of Surveying Engineering  
669 130 (2): 56-64. DOI: 10.1061/(ASCE)0733-9453(2004)130:2(56).

670 North, G.R., Bell, T.L., Cahalan, R.F. andMoeng, F. J. (1982).Sampling errors in the estimation of empirical  
671 orthogonal functions. Mon Weather Rev 110:699–706. Doi:10.1175/1520-  
672 0493(1982)110<0699:SEITEO>2.0.CO;2

673 OMB (2002). Administering or validating surveys:two protocols for use in conducting Medicaid external quality  
674 review activities. Department of Health and Human Services Centers for Medicare & Medicaid Services. Final  
675 Protocol Version 1.0.No. 0938-0786.Retrieved: July 30, 2012 from [http://dss.mo.gov/mhd/mc/pdf/p-](http://dss.mo.gov/mhd/mc/pdf/p-surveyadmin.pdf)  
676 [surveyadmin.pdf](http://dss.mo.gov/mhd/mc/pdf/p-surveyadmin.pdf).

677 Pandachuck, K., Harley, D. and Cook, D. (2004). Effectiveness of a brief workshop designed to improve  
678 teaching performance at the University of Alberta. *Acad. Med.* 79(8): 798-804.

679 Parsell, G., Spalding, R., and Bligh, J. (1998) Shared goals, shared learning: evaluation of a multiprofessional  
680 course for undergraduate students. *Medical education* 32: 304-311.

681 Peteris A., Ansis A. and Leonids, R (2012). Remote workshop for practical knowledge improvement in electrical  
682 engineering education: Computer control of electrical technology. Proceedings of the 15th International  
683 Conference on Interactive Collaborative Learning (ICL), 2012.26-28 Sept. 2012.

684 Riesen, E., Morley, M., Clendinneng, D., Ogilvie, S. and Ann Murray, M. (2012). Improving inter professional  
685 competence in undergraduate students using a novel blended learning approach. *Journal of Inter professional*  
686 *Care, Informal Healthcare London* (<http://www.ncbi.nlm.nih.gov/pubmed/22559163>)

687 Schofield, W and Breach, M (2007) *Engineering Surveying*. Taylor & Francis, Sixth Edition, 622 pp.

688 Shelton, M.T. andHudspeth, M.C. (1989).Cooperative learning in engineering through academic excellence  
689 workshops at California State Polytechnic University, Pomona. *Frontiers in Education Conference*, 1989.  
690 *Proceedings.*, 1989, 35—39,IEEE, DOI: 10.1109/FIE.1989.69367

691 Skillen, J., Merten,M., Trivett, N. and Percy, A. (1998). The IDEALL approach to Learning Development: a  
692 model for fostering improved literacy and learning outcomes for students. AARE 1998, University of Adelaide,  
693 SA.

694 Smith, K. A., Sheppard, R. D., Johnson, D. W. and Johnson, R. T., (2005), Pedagogies of engagement:  
695 Classroom-based practices, *Journal of Engineering Education* 94: 87-101.  
696

697 Snyder, L. and Snyder, M. (2008).Teaching critical thinking and problem solving skills. *Delta Pi Epsilon Journal*  
698 50 (2): 90-99.

699 Tek-Yew, L. (2012). Exploring the relationship between the Lecturer’s approaches to teaching and students’  
700 approaches to Learning. Retrieved May 31, 2012,  
701 ([http://www.curtin.edu.my/tl2011/download/papers/nonrefereed/T%20L%20Paper%20CSM%20Lew%2020](http://www.curtin.edu.my/tl2011/download/papers/nonrefereed/T%20L%20Paper%20CSM%20Lew%202011.pdf)  
702 [11.pdf](http://www.curtin.edu.my/tl2011/download/papers/nonrefereed/T%20L%20Paper%20CSM%20Lew%202011.pdf)).

703 Uren J and Price W. F. (2010) *Surveying for Engineers*. Palgrave Macmillan Limited, Fifth Edition, 806 pp.

704 Vora, D., and Markoczy L. (2011). Demographic faultiness and group performance: The role of communication.  
705 International Journal of Human Resource Management: 1-19.

706 Walker J and Awange J (2016) Surveying for Civil and Mine Engineers. Theory, Workshops, and Practicals.  
707 Springer, in press.

708 Watson, W., Kumar, K. and Michaelson, L. (1993). Cultural diversity's impact on interaction process and  
709 performance: Comparing homogenous and diverse task groups. Academy of Management Journal 36(3): 590-  
710 602.

711 Webb, N. M. (1989). Peer interaction and learning in small groups. International Journal of Educational Research  
712 13: 21-39.

713 Webster, J. (2000). Engineering Education in Australia. International Journal of Engineering Education 16(2):  
714 146-15

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717 Table 1: Qualitative questionnaire survey items for assessing the contribution of workshops to enhancing  
 718 industry-based desired skills. Here, critical thinking skills assessed the student’s critical thinking in regards to  
 719 problem solving both in the written assignments and in the field practical work.

Learning attributes	Description
Correlate theory	Did workshop helped in correlating theory to the field work?
Instrumental knowledge	Could workshops provide sufficient knowledge about the surveying instruments?
Critical thinking skills	Did workshops enhance student's independent learning and critical thinking skills?
Field work	Did the quality of teaching in the workshop help to achieve the learning outcomes for the field work?
Self assessment	Were discussions during the workshop appropriate to assess the student's knowledge and understanding of the field work?
Handle unseen problems	With the aid of the workshops, could the students effectively learn to handle unseen problems which occurred during the field work?
Communication skills	Was it possible to achieve the communication skills during discussion in the workshop?
Duration of the workshop	Was the duration of the workshop appropriate to achieve an understanding of the materials?
Size of the class	Was the size of the class for the workshop appropriate to achieve the learning outcomes of the workshop?
Feedback from the workshop	Did the feedback on the workshop help the students to achieve the learning outcomes?
Individual assignments	Did the workshops help the students in their individual mode of assignments?
Group assignments	Did the workshops help the students in their group mode of assignments?
Exam preparation	Were the workshops useful in preparing the students for the Surveying exam?
Recommend to friends	Would the students recommend the workshops to their friends?
Overall satisfied	Overall, were the students satisfied with the workshops?

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732 **Table 2:** The confidence limits for the questionnaire survey items for the students enrolled (N), N=160 (2013)  
 733 and 191 (2012) based on the sample (n), n=93 (2013) and 67 (2012). Percentage of agreement refers to the total  
 734 number of students who chose Agree (A) and Strongly Agree (SA) to a given item over (n) x 100.

Questionnaire Survey Items	% Agreement		Lower Confidence limit (%)		Upper Confidence Limit (%)	
	2013	2012	2013	2012	2013	2012
Correlate theory	97.85	97.01	96.00	93.80	99.70	100.00
Instrument knowledge	85.87	89.55	81.30	83.70	90.40	95.40
Critical thinking	93.55	91.05	90.40	85.60	96.70	96.50
Field work	94.51	91.05	91.50	85.60	97.50	96.50
Self-assessment	90.10	89.56	86.10	83.70	94.10	95.40
Handle unseen problems	77.42	67.16	72.00	58.20	82.80	76.10
Communication skills	77.17	68.65	71.70	59.80	82.70	77.50
Duration of workshop	94.57	94.03	91.60	89.50	97.50	98.60
Size of the class	89.01	86.57	84.90	80.10	93.20	93.10
Feedback on the workshop	84.95	77.61	80.30	69.60	89.60	85.60
Individual assignments	93.33	89.56	90.00	83.70	96.70	95.40
Group assignments	90.32	82.09	86.50	74.80	94.10	89.40
Exam preparation	98.90	98.50	97.50	96.20	100.00	100.00
Recommend to friends	98.91	93.75	97.60	82.40	100.00	100.00
Overall satisfied	97.85	97.02	96.00	93.80	99.70	100.00

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745 **Table 3:** Correlation between all the attributes in Table 2. Dark grey areas represented the correlations in 2012  
 746 while the light grey area represents the correlations in 2013. The correlations above 0.5 are bolded to indicate  
 747 their significance.

Learning Attributes	Correlate Theory	Instrument knowledge	Critical thinking skills	Field work	Self assessment	Handle unseen problem	Communication skills	Duration of workshop	Size of the class	Feedback on the workshop	Individual assignments	Group assignments	Exam preparation	Recommended to friends	Overall satisfied
Correlate Theory	1.00	0.58	0.49	0.60	0.26	0.31	0.27	0.36	0.42	0.40	0.37	0.26	0.49	0.43	0.55
Instrument knowledge	0.56	1.00	0.58	0.57	0.39	0.50	0.37	0.47	0.48	0.53	0.34	0.37	0.36	0.46	0.59
Critical thinking skills	0.57	0.82	1.00	0.50	0.31	0.46	0.43	0.39	0.28	0.49	0.40	0.30	0.33	0.29	0.47
Field work	0.63	0.51	0.50	1.00	0.49	0.33	0.47	0.54	0.49	0.50	0.40	0.37	0.52	0.62	0.67
Self assessment	0.39	0.41	0.31	0.45	1.00	0.38	0.60	0.44	0.48	0.43	0.55	0.61	0.36	0.45	0.51
Handle unseen problems	0.26	0.42	0.25	0.28	0.27	1.00	0.32	0.34	0.37	0.46	0.28	0.49	0.14	0.31	0.53
Communication skills	0.34	0.44	0.38	0.25	0.29	0.24	1.00	0.43	0.35	0.47	0.52	0.47	0.32	0.34	0.38
Duration of workshop	0.41	0.38	0.35	0.39	0.50	0.27	0.29	1.00	0.46	0.47	0.48	0.44	0.56	0.61	0.55
Size of the class	0.45	0.38	0.37	0.41	0.49	0.09	0.30	0.57	1.00	0.31	0.37	0.47	0.36	0.37	0.54
Feedback on the workshop	0.19	0.33	0.28	0.33	0.17	0.36	0.35	0.31	0.35	1.00	0.47	0.33	0.41	0.41	0.56
Individual assignments	0.57	0.24	0.24	0.52	0.43	0.19	0.18	0.37	0.45	0.30	1.00	0.70	0.51	0.47	0.59
Group assignments	0.42	0.29	0.35	0.41	0.37	0.15	0.20	0.34	0.38	0.36	0.63	1.00	0.29	0.44	0.54
Exam preparation	0.58	0.39	0.39	0.60	0.54	0.16	0.21	0.41	0.54	0.31	0.54	0.47	1.00	0.75	0.64
Recommended to friends	0.72	0.60	0.64	0.62	0.74	0.19	0.57	0.74	0.74	0.29	0.82	0.52	0.95	1.00	0.75
Overall satisfied	0.65	0.43	0.41	0.58	0.42	0.19	0.25	0.44	0.57	0.19	0.57	0.40	0.66	0.72	1.00

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